WISHKAH RIVER BRIDGE **HAER No. WA-92**

(Wishkah River Bridge at Wishkah Street)
U.S. Route 12 (Wishkah Street) spanning the
Wishkah River
Aberdeen
Grays Harbor County
Washington

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

PHOTOGRAPHS

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HISTORIC AMERICAN ENGINEERING RECORD
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HISTORIC AMERICAN ENGINEERING RECORD

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Location:	U.S. Route 12 (Wishkah Street), spanning the Wishkah River, Aberdeen, Grays Harbor County, Washington, beginning at mile point 0.08.
	UTM: 10/438340/5302760 Quad: Aberdeen, Wash.
Date of Construction:	1924
Engineer:	M. M. Caldwell, consulting engineer. Strauss Bascule Bridge Company of Chicago, designer.
Fabricator:	Puget Sound Bridge and Dredging Company of Seattle.
Owner:	Built for the city of Aberdeen. Now owned by the Washington Department of Highways, since 1977 the Washington State Department Transportation, Olympia, Washington.
Present Use:	Vehicular and pedestrian traffic.
Significance:	The bridge is a classic example of a patented Strauss "heel-trunnion" bascule bridge type.
Historian:	Wm. Michael Lawrence, August 1993

History of the Bridge

The twin cities of Aberdeen and Hoquiam are located on a low-lying flatland at the head of Grays Harbor on the Pacific Coast. They once were bustling harbor towns, whose fortunes depended greatly on the lumber industry. The Wishkah River is one of several waterways which flow through the two towns and have been used in the past to dock ocean-going vessels. Any bridge spanning the river will have little clearance below it, unless it is set on high approaches, as is the case with the nearby Hoquiam River Bridge (HAER No. WA-93). The alternative is to construct a bascule bridge with through trusses which will not hinder the movement of small vessels and which can be opened for large ones. This is the solution the city of Aberdeen chose when it built the Wishkah River Bridge, also known as the Wishkah River Bridge at Wishkah Street.[1]

The *Pacific Builder and Engineer*, a regional contractors' journal, in its weekly "Construction News," reported developments leading to the construction of the bridge. On 25 May 1923, it briefly noted that the Aberdeen city council was considering an ordinance which would submit a bond referendum to the voters in a special election, to build a structure over the Wishkah River at Heron Street.[2] The council did not pass the measure until a new state law regulating such bond issues went into effect on 6 June 1923.[3] On July 30, the referendum passed. It was to raise $200,000 for this bridge and an equal amount for another bridge over the Chehalis River. The city decided, however, to change the site for the Wishkah River Bridge from Heron St. to Wishkah Street, just one block to the north.[4]

The city selected M. M. Caldwell, of Seattle, to be the consulting engineer superintending the construction, and the Strauss Bascule Bridge Company, of Chicago, designing the structure. Preliminary plans called for a 40'-wide bridge with 27', curb-to-curb, for vehicular traffic, 3' wider than the final design.[5] The city eventually decided on a single-leaf bascule, because it would cost less than a double-leaf span.[6] Although the city and the engineers planned to call for bids in January of the following year, they postponed this action until the following summer.[7].

The plans were changed shortly before the announcement, with the addition of concrete retaining walls along the banks and wider approaches on the east side.[8] On 9 July 1924, the city council voted to send out requests for bids, with the closing on 30 July.[9] The low bid was at $183,635, submitted by the Puget Sound Bridge and Dredging Company of Seattle,[10] a major engineering and construction company in the region. The company built the bridge that year.

The Wishkah River Bridge has continued to serve as a vehicular and pedestrian bridge to the present day. The state of Washington purchased the bridge in 1935, under the authority of a 1935 act of the state legislature.[11] In 1949, the Washington Department of Highways built a swing bridge just to the south at Heron Street, the site originally intended for the Wishkah River Bridge at Wishkah Street.[12] Both are part of U.S. 12, with the Wishkah handling westbound traffic and the Heron Street Bridge handling eastbound traffic.

Design and Description

The Wishkah River Bridge is a classic example of a Strauss "heel trunnion" bascule, one of the three basic Strauss bascule bridge types, the others being the "overhead counterweight" and the "underneath counterweight." Like all bascule bridges, these depend on a counterweight to balance the load of the leaf, or movable span, enabling a relatively small motor to move open and close the bridge.

In the simplest type of bascule bridge, the leaf, or movable span, consists of a truss with a counterweight attached to its "heel." The truss and counterweight are balanced on a single pivot or trunnion, located at their center of gravity. The principle is the same as that of a see-saw or balance beam scale. The leaf can be rotated about the trunnion by a minimum amount of power, the effect of gravity having been practically eliminated. The simple trunnion or Chicago bascule bridge type works in such a manner.[13]

Strauss heel trunnion bascule bridges differ in that the leaf and the counterweight are supported by and rotate about separate trunnions (fig. 1). The leaf consists of a through truss. It is supported by and rotates about a main trunnion at its "heel," which in this case is at the panel point where the end post meets the bottom chord. A tower stands at the heel, straddling the roadway approach to the leaf. It supports the main trunnion at one end of its base and another trunnion at its apex. This, the counterweight trunnion, supports a counterweight frame. A counterweight link, with pins at each end, connects this frame to the top chord of the leaf truss. The counterweight hangs from the frame on the other side of the tower, above the roadway. It indirectly balances the leaf, through the counterweight frame and link. As with the simple trunnion type, this balance makes is easy to move the leaf and the counterweight with a minimum amount of power. The balance depends, however, on the arrangement of the two trunnions and link pins at the four corners of a parallelogram, whose configuration changes throughout the movement of these parts, so that the moments about the two trunnions are always equal.[14]

The Wishkah Bridge is a typical Strauss heel trunnion bascule. Its single leaf consists of a 145' Warren through truss with lateral overhead bracing and inclined end posts. As with all structural members in this bridge, it is composed of rivetted steel pieces. The truss supports a 27'-wide road deck at the inside and two 5' wide sidewalks on either side.[15] Its west end bears on a pair of steel shoes anchored to a reinforced-concrete abutment. At these shoes, the truss is held down with a locking device when the leaf is closed. The east end is supported at each side by a main trunnion. This trunnion bears on a lower corner of the counterweight tower. When the lock is disengaged, the truss is free to tilt up, rotating about the main trunnion at its east end, if enough force is applied.

In its side elevation, the triangular tower is a right triangle, with 42'-long legs.[16] The horizontal, consisting of a small truss, supports a deck approaching the movable span. The hypotenuse serves as a diagonal brace and the vertical leg acts like a post. At the apex of the triangular frame is the counterweight trunnion. This triangular tower bears on two slender reinforced-concrete piers, located at its two lower corners.

The counterweight trunnion supports one corner of the counterweight frame. In its side elevation, the outline of the frame is that of an irregular polygon, with four members radiating from the counterweight trunnion and three others joining them at their ends. The massive concrete counterweight, also irregular in its side elevation, hangs from the east end of this frame. At the west end of the frame is the first link pin. A 50'-long counterweight link extends from this pin down to the second link pin. This second link pin is attached to the eastern-most panel point of the top chord of the through truss or leaf.

The eastern end post of the Warren truss, the hypotenuse of the fixed right-triangular tower, the western-most side or member of the counterweight frame, and the counterweight link together form a parallelogram with the trunnions and pins at the corners. As the bridge opens and closes, the angles at the pivot points change, but the four parts still form a parallelogram. This configuration is important, for it maintains the balance between the counterweight and leaf at all times. As with any bascule bridge, this balance makes it possible to lift the leaf with a minimum amount of power, the only forces to be overcome being inertia, and friction, assuming the balance is perfect.

The manner in which this balance occurs throughout the movement of the parts is not as simple as in a see-saw or a simple trunnion bascule. During the bridge's operation, the center of gravity of the leaf or truss is constantly moving, vertically and horizontally. This is also true of the counterweight. As a result, the moment about each trunnion changes as the leaf and counterweight move.

In a heel trunnion bascule, the counterweight is located so that the moment arm it creates about its trunnion is always equal to that created by the truss about the main trunnion, as long as the two moment arms are parallel with each other. This condition is made possible by virtue of the parallelogram arrangement of the link pins and trunnions. The two moments always counterbalance each other, maintaining the necessary balance between the counterweight and leaf.

This arrangement also keeps the center of gravity of the entire bridge constant in the horizontal direction, midway between the two trunnions and midway between the two piers, as well, one pier being located directly below each trunnion. As such, the load of the entire bridge is divided equally between the two piers at all times. Each pier carries half of the dead load of the bridge at all times and nothing more, minimizing its necessary strength and cost. As explained by a representative of the Strauss company, "For this reason the foundations of a bridge of this type are simple and economical. Moreover, by separating the reactions of moving leaf and counterweight the evils of concentrating the entire load on one pier are avoided."[17]

A rack or operating strut at each side of the bridge moves the leaf and the counterweight. Each strut is connected to the Warren truss by means of a pivot near the second link pin and extends east to a pinion just to the side the machinery room, a sheet metal building located inside the triangular tower and above the roadway (fig. 2). In some bridges of this type, the arrangement is reversed, with the machinery and pinion near the hip of the truss. The operating strut is a straight cast piece with teeth, which mesh with the teeth of the pinion. The pinion, which is basically a large gear, is on a shaft between two bearings, a rather unique arrangement, for in many bridges the pinions are on cantilever ends of their shafts (fig. 2).

A series of shafts and reduction gears transmit power from the equalizer shaft to the pinion shaft. At its end is a gear which is part of the equalizer, a device similar to the differential of a car, which not only transmits power from the motors, but prevents undue stress on the two equalizer shafts and gears due to any differences in loading from the two sides of the leaf. The entire sequence is repeated on either side of the equalizer. The equalizer shaft is equipped with emergency solenoid brakes. Two electric motors drive the equalizer and, through it, the rest of the drive train. As originally built, a 40 horsepower engine, running at 1,000 revolutions per minute and equipped with a clutch and set of reversing gears, could supply power when electric current was not available.

The loads are sufficient to hold the leaf down when it is closed. Nevertheless, two end locks at the west end of the leaf secure it to the bearing plates (fig. 3). These are located under the deck, at its corners. Each consists of a cast steel hook whose shaft fits into the endpost of the leaf, and a cast steel catch, which is attached to the bearing plate. When the leaf is lowered, the hook meets the sloping top of the catch, which pushes it back until it reach the mouth of the catch. The hook then snaps forward into the mouth. A shaft is pin-connected to the back of the hook, extending through sleeves in the eastward direction. A phosphor bronze spring around the shaft pushes the hook into the mouth of the catch and helps hold it in place.

An eccentric on the shaft of the hook serves as a lever, which is connected by a link to another lever, at a gear train. Both locks are driven by a single 3.2 h.p. motor, with a speed reducer, at the one side of the bridge, with a shaft transmitting power to the lock farthest from the motor. The motor is equipped with a solenoid brake on its shaft. The operation of the motor and these driving mechanisms both opens the lock and tightens it shut. In the event of an electrical power failure, the bridge tender can use a hand winch, located in the end post of the truss above the deck, to operate the mechanism.

A pneumatic buffer (fig. 4) is mounted on the end floor beam between the two locks. This consists of a 12" diameter piston with a 12" vertical stroke. As the bridge lowers and approaches the pier, the bottom end of the shaft meets a steel plate anchored to the pier, and air pressure within the cylinder reduces the impact of the leaf as it closes. This helps prevents stress on the machinery moving the leaf.[18]

The bridge tender controls the operating mechanism, locks, and the gates at either end of the bridge at a panel whose controls are designed to prevent the tender from doing anything out of sequence. The tender must stand on dead-man pedals during the operation, otherwise the motors stop and the emergency solenoid brakes automatically lock, stopping the movement of the bridge. Limit switches stop the motors if the mechanisms begins to exceed their full range of operation.[19] The original control room housing this panel originally was located on a platform cantilevering beyond the sidewalk south of the triangular tower.[20]

Three slender reinforced-concrete piers, extending the full width of the truss, support the structure at the counterweight tower and at the leaf bearing plates. Wooden cribbing in the water protects the piers from collisions with boats; the effective channel width, at least when the bridge was built, was 125'.[21]

The approaches to the bridge are also of reinforced-concrete. These are concrete T-beams on bents. The east approach consists four spans, one at 17' -5", one at 10', one at 16', and one at 14' long. The western approach is more complicated and irregular in plan, a platform supporting the intersection for two streets.[22]

The advantage of the heel trunnion bascule bridge, besides the economy and simplicity of the piers supporting it, is that it does not require a counterweight pit or high approaches. Many of these bridges were used as railroad structures, since any reduction in grade changes is advantageous in railroad construction.

A principal disadvantage is the number of intermoving parts, including the swinging counterweight.[23] Another is aesthetic. Most people would not consider this bridge very attractive, with its machinery room, structure, and huge counterweight in full view. John Alexander Low Waddell, for example, wrote in his classic text on bridge engineering that:

> A good many bridges of the Strauss type have been built, and from all that can be learned they are operating well; but they are specially deficient from the aesthetic point of view. However, that cuts very little figure, as no bascule bridge ever designed can be claimed to be a thing of beauty. If it will open quickly and keep in good order, that is about all that can be expected of it.[24]

The Wishkah River Bridge has all of the glamour of a dockside crane. This is appropriate, perhaps, for the bridge built in a busy, hard-working, pragmatic harbor town rather than a more urban setting. The geometric pattern of the truss, triangular tower, and counterweight frame, however, has a certain unity that can be pleasing to the eye.

Waddell considered the heel trunnion bascule type a derivative of the straight overhead counterweight type, the first kind of bascule bridge patented and built by Joseph Strauss and the Strauss Bascule Bridge Company. The first of the type, completed in 1905, was a bridge for the Wheeling and Lake Erie Railroad over the Cuyahoga River, in Cleveland, Ohio. Strauss filed for a patent in 1907, which was granted three years later.[25]

The two types are similar in that they both involve the location of four pivot points at the corners of a parallelogram whose angles change with the motion of the leaf and counterweight. In the straight overhead counterweight type, however, the counterweight is hung below a pivot point that is diagonally opposite the main trunnion and as it moves up and down, its orientation remains the same, unlike the counterweight of the heel trunnion type (fig. 5). Or, as Waddell would put it, "this [arrangement] enables the said counterweight to move parallel to itself at all times."[26] The use of the parallelogram arrangement is a principle underlying most Strauss movable bridge types.

The heel trunnion type was developed by around 1910. Strauss was granted many patents during his career; those covering this bascule type would include Patents No. 1,211,639 and 1,211,640, both filed late in 1911.[27] By the following year, Philip L. Kaufman, an official of the Strauss company could state that the company had constructed eight large bridges of this type and that eight more were under construction. This announcement, along with the first description of the heel trunnion bascule type in an engineering or contractors' journal, appeared in an *Engineering News* article dated 2 May 1912.[28] By 1926, Strauss bascule bridges, including this type, outnumbered those based on designs by any other company or engineering firm.[29] The Wishkah River Bridge is one of the 267 movable bridges designed by this important company between 1905 and 1927.[30]

<u>Repair and Maintenance</u>

The Washington Department of Highways took over maintenance of the Wishkah River Bridge when the state purchased the structure in 1935. Maintenance records indicate some of the changes made over the years and the sorts of maintenance concerns such a bridge entails.

Perhaps the most significant modification concerns the decking. The original deck was of wooden planks and timbers. The highway department had to replace it, shortly after purchasing the bridge, in 1937. Within a decade, this deck required repairs such as resealing, in 1942, and replacing some of the timbers in 1943 and 1944.

The replacement of the wood decking with a steel grid, in 1946, effectively eliminated this problem. This work also included the installation of new sidewalks, presumably the concrete walks that are now a part of the bridge. Cascade Contractors, Inc. of Seattle performed this service. Such steel grids have extended the lives of many bascule bridges despite more recent heavier traffic loads.

Another significant change was the removal of the original control room and the construction of a new control tower on the bank southwest of the bridge in 1950, by the Industrial Electrical Service. The tower also houses controls for the Heron Street swing bridge, one block south of the Wishkah River Bridge. The work also included a general repair of the electrical systems. This was part of a major state highway department program to upgrade the electrical systems in the movable bridges owned by the state.[31]

As the riveted structure of this 351 ton bridge presents many surfaces and angles which can retain moisture, it requires frequent painting. On the average, the Wishkah River Bridge gets a new coat of paint every ten years. The state had the bridge painted and coal tar epoxy applied in upturned chord members in 1990, all at a cost of $43,000.

At one time a special gate was added to the bridge that lifted up at the edge of the western approach when the bridge opened, preventing automobiles from plummeting into the river. The highway department removed this in 1986.

The machinery has not needed any attention other than regular greasing of the bearings and gears, which is not surprising since these are housed inside a metal building and, as the river does not carry heavy boat traffic any longer, the bridge does not open very often.[32]

One minor alteration attracts the attention of anybody driving down Wishkah Street from the east. A huge welcoming sign hangs from the face of the counterweight, greeting visitors to Aberdeen.

Data Limitations

Drawings for this bridge survive at Records Control, Washington State Department of Transportation, and at the Bridge Preservation Section, WSDOT, both in Olympia, making it possible to describe and analyze the structure. Philip Kaufman's 1912 article in the *Engineering News* was also helpful, with its explanation of the parallelogram arrangement of the trunnions and pivots in the heel trunnion bascule type. Various textbooks had sections regarding bascule bridges, written by Conde B. McCullough and J. A. L. Waddell, provided information about the Strauss bascule bridge types. Otis Hovey's book, *Movable Bridges*, actually explains the machinery used at the Wishkah Bridge itself.

The brief announcements in *Pacific Builder and Engineer*, concerning the Wishkah Bridge prior to its construction, helped date the bridge. Articles concerning bridges were found in newspaper clipping files at the Washington State Library in

Olympia, the Washington State Historical Society library in Tacoma, the Seattle Public Library, the Special Collections Room at the University of Washington Library in Seattle, and the Museum of History and Industry, also in Seattle. They had nothing concerning the Wishkah River Bridge. Unfortunately, time did not permit a visit to Aberdeen to look for more information. Articles in the various biographical dictionaries were the basis for the brief appendix on Joseph B. Strauss.

Project Information

This project is part of the Historic American Engineering Record (HAER), National Park Service. It is a long-range program to document historically significant engineering and industrial works in the United States. The Washington State Historic Bridges Recording Project was co-sponsored in 1993 by HAER, the Washington State Department of Transportation (WSDOT), and the Washington State Office of Archeology & Historic Preservation. Fieldwork, measured drawings, historical reports, and photographs were prepared under the general direction of Robert J. Kapsch, Ph.D., Chief, HABS/HAER; Eric N. DeLony, Chief and Principal Architect, HAER; and Dean Herrin, Ph.D., HAER Staff Historian.

The recording team consisted of Karl W. Stumpf, Supervisory Architect (University of Illinois at Urbana-Champaign); Robert W. Hadlow, Ph.D., Supervisory Historian (Washington State University); Vivian Chi (University of Maryland); Erin M. Doherty (Miami University), Catherine I. Kudlik (The Catholic University of America), and Wolfgang G. Mayr (U.S./International Council on Monuments and Sites/Technical University of Vienna), Architectural Technicians; Jonathan Clarke (ICOMOS/Ironbridge Institute, England) and Wm. Michael Lawrence (University of Illinois at Urbana-Champaign), Historians; and Jet Lowe (Washington, D.C.), HAER Photographer.

APPENDIX

Joseph Baermann Strauss and the Strauss Bascule Bridge Company

Joseph Baermann Strauss was one of the most important engineers and bridge builders of the early twentieth century. He was born in Cincinnati, Ohio, on 7 January 1870. He received a degree of Civil Engineering at the University of Cincinnati in 1892 and spent the first years of his career in a variety of positions: as a draftsman for the New Jersey Steel and Iron Company, as a teacher at the University of Cincinnati, as an inspector, detailer, and estimator for the Lassig Bridge Company of Chicago; as a designer and squad boss for the Chicago Sanitary District, and as principal assistant engineer in the office of Ralph Modjeski, also in Chicago. While working for the city of Chicago, he gained considerable experience with railroad bridges and viaducts and was also exposed to the new field of bascule bridge design.

He went into private practice in 1899 as a consulting engineer, then in 1902 founded the Strauss Engineering Corporation, for the general design of bridges, viaducts, and buildings, with himself as president and chief engineer. During these early years of private practice, he developed a type of concrete stock house for the Universal Portland Cement Co. and was credited with introducing ribbed concrete arch bridges in the United States. He eventually specialized in movable and long span bridges and renamed his company the Strauss Bascule Bridge Company.

At that time, bascule bridges were rarely used and were relatively short-spanned because of the expense of the cast-iron counterweights used in the structures. Strauss is credited with introducing the idea of using concrete counterweights of larger bulk but lesser cost. This required a new design to prevent the larger counterweights from interfering with the operation of the bridge. The key to Strauss' designs was the use of four pins arranged in a parallelogram which changed configuration during the movement of the span and the counterweight, making it possible to separate the two from each other rather than fixing the counterweight in the heel of the leaf truss, as is the case with many bascule bridges.

In 1904, Strauss developed the first of his bascule bridge types, the vertical overhead counterweight type. He built the first example of this type, built in 1905 for the Wheeling and Lake Erie Railroad in Cleveland, was a 150' structure. Within seven years he also invented the "heel trunnion type," the "underneath counterweight type," and the "simple span type." By 1927 he designed 267 bascule bridges of these types throughout the world, for roads, railroads, and even, in one case, a footbridge.[33]

Many of these established records for span lengths. He also developed a vertical lift bridge without cables or counterweights and a horizontal draw bridge.

Strauss designed quite a number of other bridges besides movable spans as well, including the Columbia River Bridge at Longview, Washington (1929, HAER No. WA-89), the longest cantilever in North America at the time. He was co-designer for the 2-mile Montreal-South Shore Bridge for Harbour Community, Montreal (1930), designing engineer for the bascule span of the Arlington Memorial Bridge in Washington, D.C. (1932), construction engineer for the George Washington Memorial Bridge in New York City, at its time was the second longest single span in the world, and construction engineer for the 1,650' Bayonne Arch, also in New York City. He is best known as the chief engineer for the Golden Gate suspension bridge in San Francisco, built in 1929. Strauss and his company were responsible for nearly 500 bridge designs.

He was a prolific inventor, and not only of bridge designs. His innovations, many of which were patented, include a bascule-door hanger, a searchlight that was widely used during World War I, a steel glass building system, a design for a rotating restaurant tower, and a rapid transit system called the Airtram. He developed a yielding barrier, said to be the first practical device to stop automobiles at railroad crossings, which the U.S. Navy adapted for automatically stopping planes landing on carrier decks. It was also the basis for a safety net Strauss designed, which saved the lives of 21 workmen during construction of the Golden Gate bridge.

One of his more unique designs was for the "Aeroscope," an amusement device at the Panama-Pacific international exposition in San Francisco in 1915. Essentially, this was a bascule leaf on a rotating platform which lifted a two-story car, carrying 150 people, up to 260' above the ground.[34] He designed a disappearing tower at Fort Hancock in New York Harbor which was similar in principle, consisting of an arm that raised and lowered, carrying a 60-inch searchlight.

Strauss was a member of several engineering and professional societies. In addition to his achievements as an engineer, he was interested in art, poetry, and literature, contributing poems and articles to many magazines. Some of his poems were set to music. He founded the American Citizenship Foundation, which established an academy where more than 600 boys were taken off the streets and had the chance to take courses in vocational, physical, and citizenship training with the hopes of making them productive individuals. He died of a heart attack in Los Angeles, California, on 16 May 1938.[35]

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Captions for Figures

g = center of gravity for the leaf
g' = center of gravity for the counter weight
P = load of the leaf
W = load of the counterweight
Px = moment about the main trunnion A
Wy = moment about the counterweight trunnion C

Px = Wy at all times.

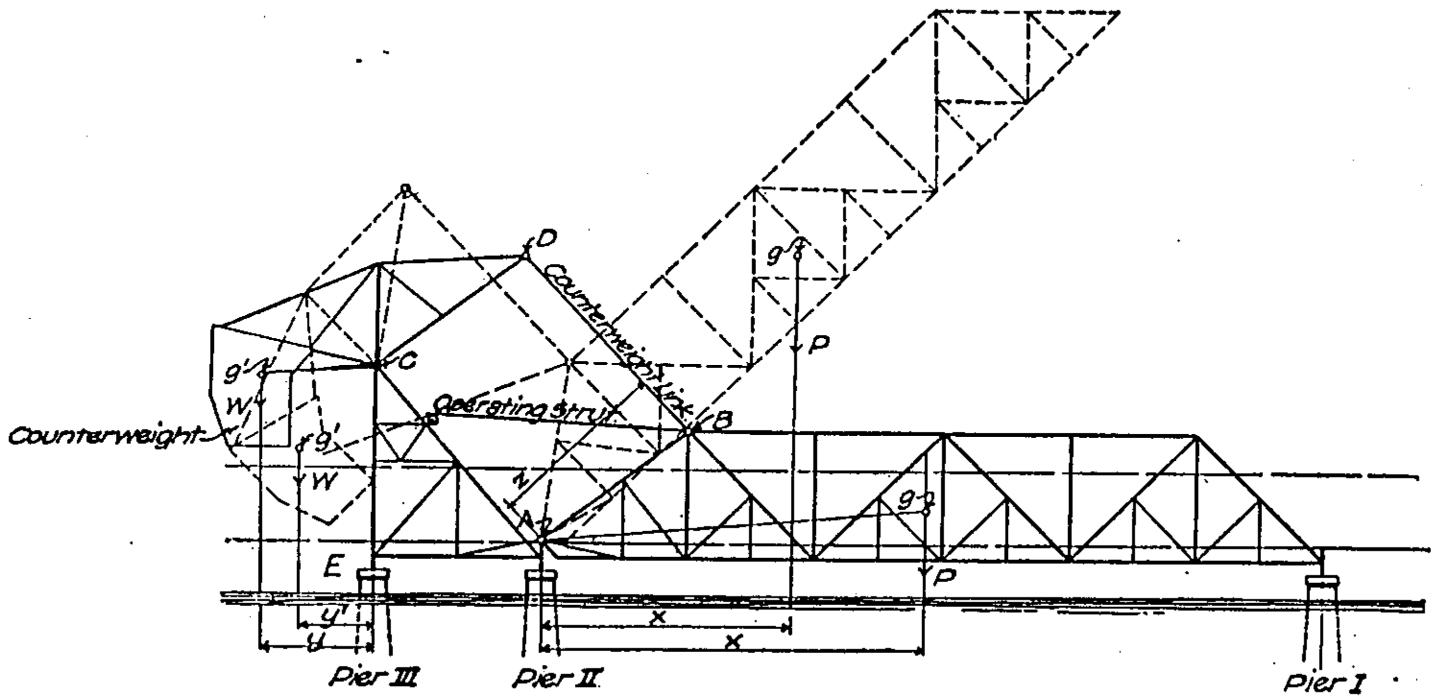
Figure 1: Schematic diagram of the Strauss heel trunnion bascule bridge type. From Otis Ellis Hovey, *Moveable Bridges* (New York: John Wiley & Sons, 1926).

Figure 2: Wishkah River Bridge operating machinery. From Otis Ellis Hovey, *Moveable Bridges* (New York: John Wiley & Sons, 1926).

Figure 3: Wishkah River Bridge end lock. From Otis Ellis Hovey, *Moveable Bridges* (New York: John Wiley & Sons, 1926).

Figure 4: Wishkah River Bridge pneumatic buffer. From Otis Ellis Hovey, *Moveable Bridges* (New York: John Wiley & Sons, 1926).

Figure 5: Schematic diagram of the Strauss overhead counterweight bascule type. From Otis Ellis Hovey, *Moveable Bridges* (New York: John Wiley & Sons, 1926).



g = center of gravity for the leaf
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WISHKAH RIVER BRIDGE.
OPERATING MACHINERY.

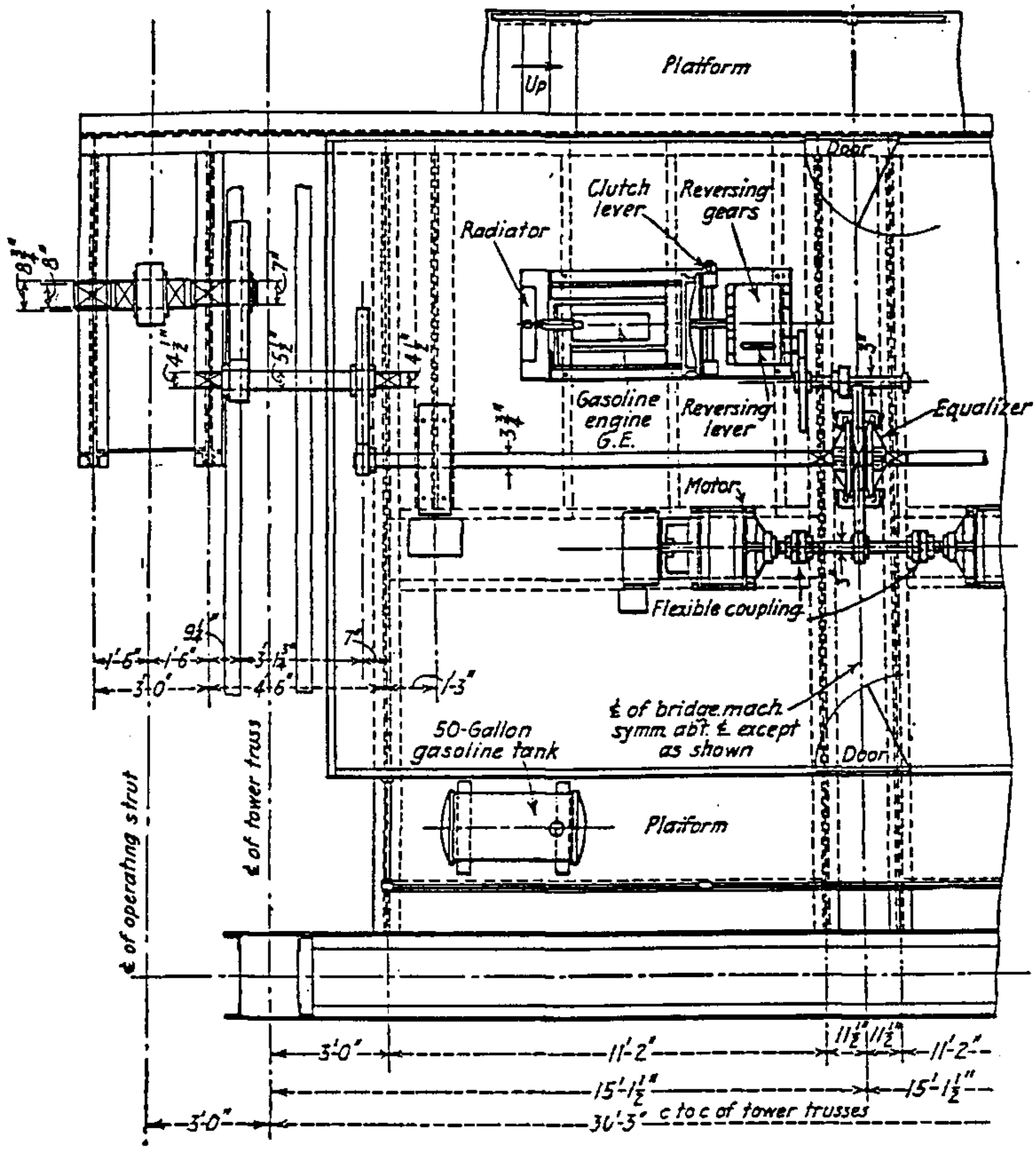


Figure 2: Wishkah River bridge operating machinery. From Otis Ellis Hovey, *Moveable Bridges* (New York: John Wiley & Sons, 1926).

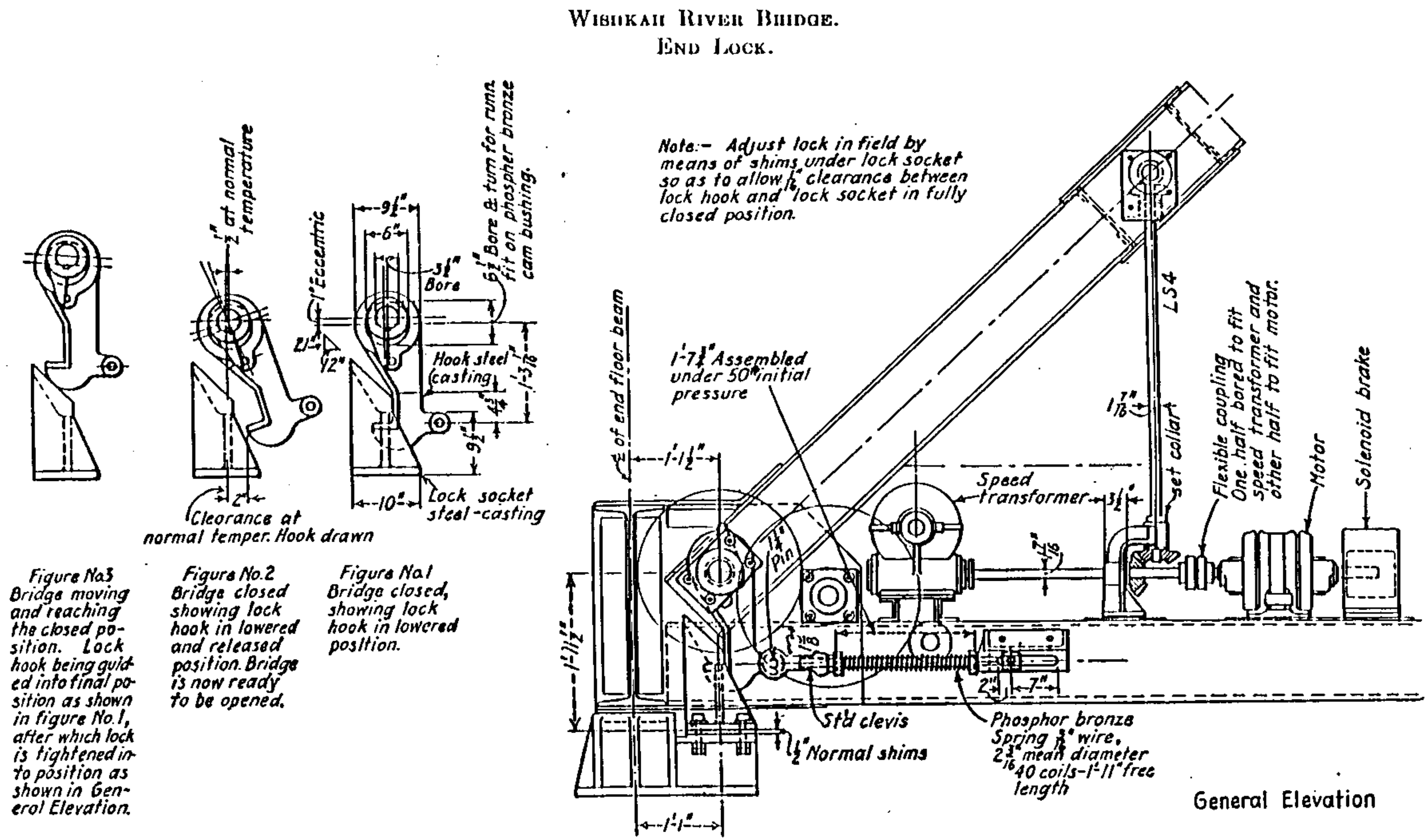


Figure 3: Wishkah River bridge end lock. From Otis Ellis Hovey, *Moveable Bridges* (New York: John Wiley & Sons, 1926).

WISHKAH RIVER BRIDGE.

PNEUMATIC BUFFER.

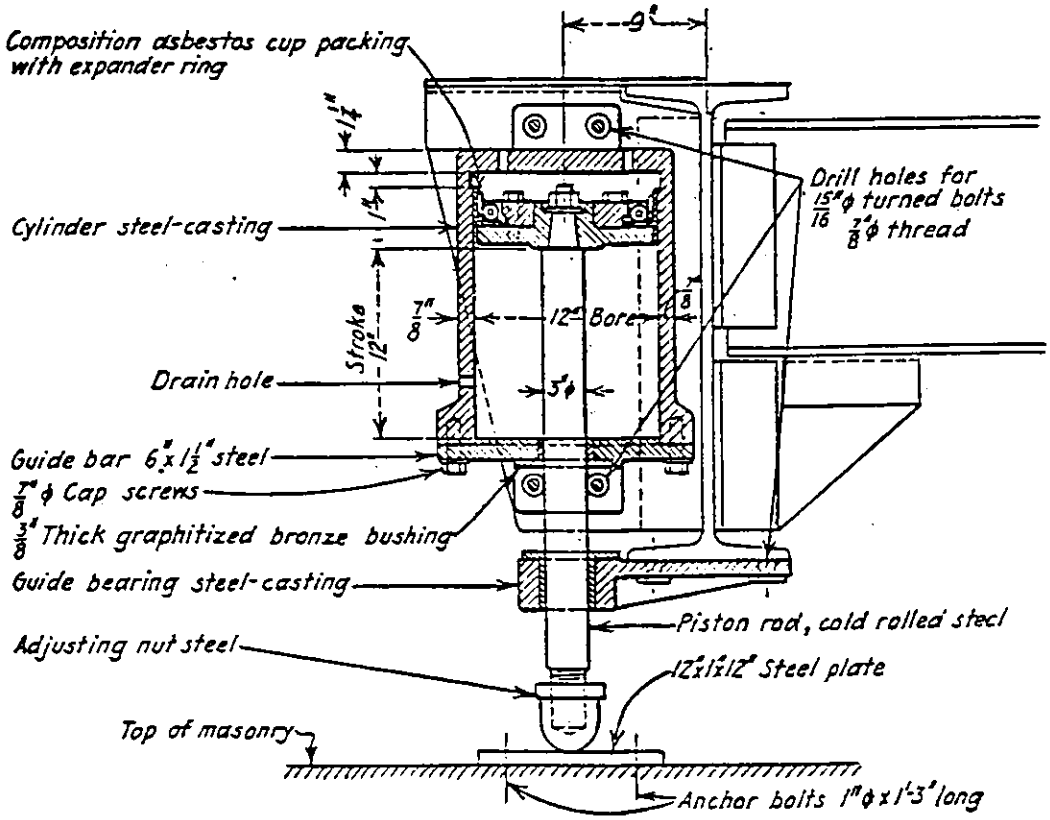
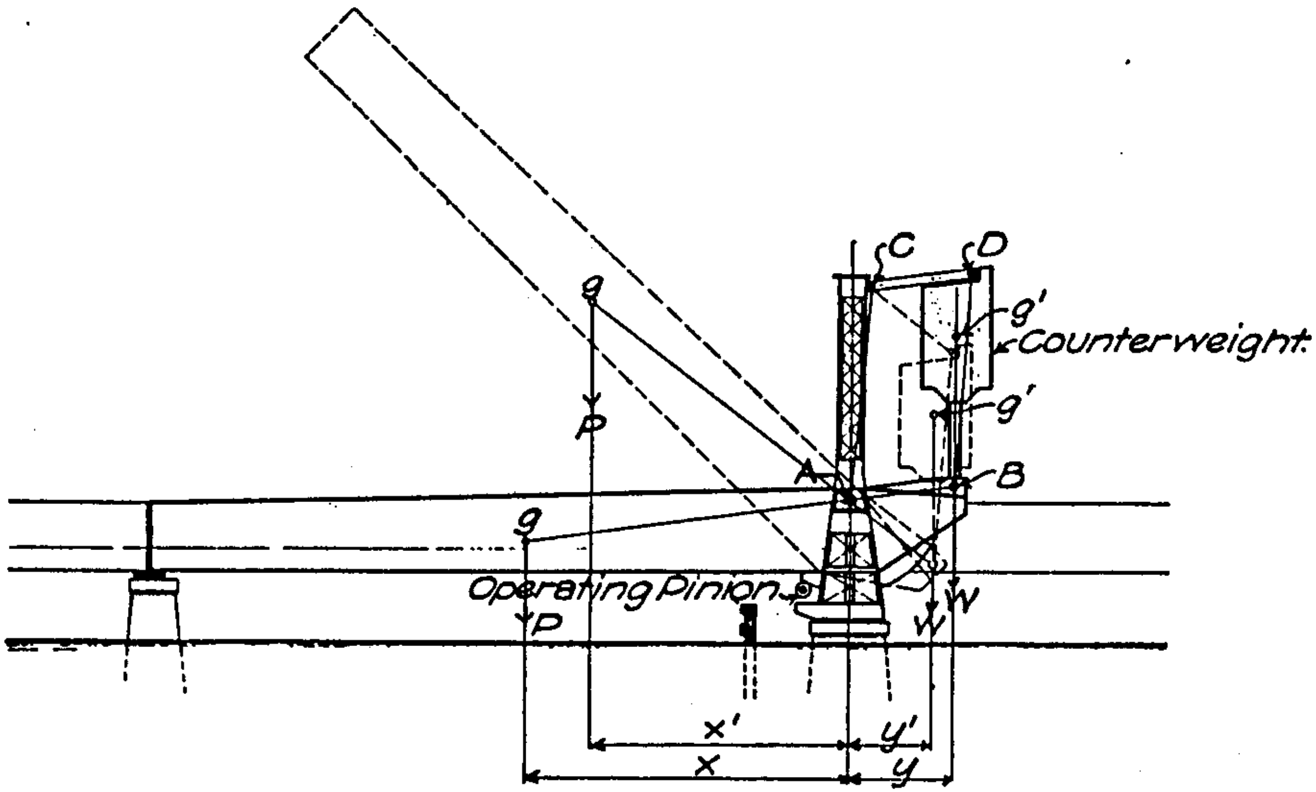


Figure 4: Wishkah River bridge pneumatic buffer. From Otis Ellis Hovey, *Moveable Bridges* (New York: John Wiley & Sons, 1926).



g = center of gravity for the leaf
g' = center of gravity for the counter weight
P = load of the leaf
W = load of the counterweight
Px = moment about the main trunnion A
Wy = moment about the counterweight trunnion C

Px = Wy at all times.

Figure 5: Schematic diagram of the Strauss overhead counterweight bascule type. From Otis Ellis Hovey, *Moveable Bridges* (New York: John Wiley & Sons, 1926).

ENDNOTES

[1] The nameplate on the bridge uses the longer name.

[2] "Construction News," *Pacific Builder and Engineer* 29 (25 May 1923): 13.

[3] "Construction News," *Pacific Builder and Engineer* 29 (8 June 1923): 1; and 29 (29 June 1923): 23.

[4] "Construction News," *Pacific Builder and Engineer* 29 (3 August 1923): 1. The entry states the election was "on Tuesday" and the *Pacific Builder and Engineer* always came out on Saturdays.

[5] "Construction News," *Pacific Builder and Engineer* 29 (24 August 1923): 13.

[6] "Construction News," *Pacific Builder and Engineer* 29 (24 November 1923): 16.

[7] "Construction News," *Pacific Builder and Engineer* 29 (1 December 1923): 13; and 30 (7 June 1924): 12-13.

[8] "Construction News," *Pacific Builder and Engineer* 30 (14 June 1924).

[9] "Advertisements for Bids," *Pacific Builder and Engineer* 30 (19 July 1924): 11.

[10] "Advertisements for Bids," *Pacific Builder and Engineer* 30 (16 August 1924): 6.

[11] "Wishkah River Bridge, No. 12/12N," Kardex Card File, and Bridge Inspection Reports in Correspondence Files, Bridge Preservation Section, Washington State Department of Transportation, Olympia, WA [WSDOT].

[12] Ibid.

[13] C. B. McCullough, "Designs and Types of Bascule Bridges" in George A. Hool and W. S. Kinne, eds., *Movable and Long-Span Steel Bridges* (New York: McGraw-Hill Book Co., 1923), 20.

[14] Philip Kaufman, "The 'Heel Trunnion' Bascule Bridge," *Engineering News* 67 (2 May 1912): 830. Where possible, Kaufman's terminology is used, with the assumption that these are terms used by the Strauss Bascule Bridge Company.

[15] Strauss Bascule Bridge Company, "Wishkah Street Bridge over Wishkah River," sheet 21, held by Records Control, WSDOT.

[16] Strauss Bascule Bridge Company.

[17] Kaufman, "The 'Heel Trunnion' Bascule Bridge," 830. See also Otis Ellis Hovey, *Moveable Bridges*, vol. 1 (New York: John Wiley & Sons, 1926), 121-23; C. B. McCullough, "Designs and Types of Bascule Bridges," 25; and J. A. L. Waddell, *Bridge Engineering*, vol. 1 (New York: John Wiley & Sons, 1916), 704-06. All of these sources have illustration that are helpful in understanding the parallelogram arrangement of the pivot points.

[18] This description of the mechanical equipment is based on descriptions and illustrations of the machinery of the Wishkah River bridge in Hovey, *Moveable Bridges*, vol. 2, *Machinery* (New York: John Wiley & Sons, 1926), 69-75.

[19] This information was obtained during a site visit.

[20] Strauss Bascule Bridge Company.

[21] Ibid.

[22] Washington State Highway Department, "Primary State Route No. 9, Wishkah River Bridge, Aberdeen), held by Records Control, WSDOT.

[23] C. B. McCullough, "Designs and Types of Bascule Bridges," 25.

[24] Waddell, 714.

[25] Patent No. 894,239, Joseph B. Strauss, Chicago, Ill., filed 28 March 1907.

[26] Waddell, 704. For discussions of the overhead counterweight type see also, Hovey, 116-7 and McCullough, 24-5.

[27] Patent No. 1,211,639. Joseph B. Strauss, Chicago, Ill., filed 29 December 1911; and Patent No. 1,211,640, filed 29 December 1911. Strauss eventually filed suits against the cities of Chicago and Seattle, and the Schertzer Bascule Bridge Co. for patent infringement. The large number of Strauss patents seems to have made it easy for others to infringe on them in one way or another.

[28] Kaufman, "The 'Heel Trunnion' Bascule Bridge," 830.

[29] Hovey, *Moveable Bridges,* vol. 1, *Superstructure* (New York: John Wiley & Sons, 1926), 116.

[30] For a short biography of Joseph Strauss and a brief history of his company, see Appendix.

[31] Washington Department of Highways, *Twenty-third Biennial Report of the Director of Highways, 1948-1950*, 24.

[32] "Wishkah River Bridge, No. 12/12N," Bridge Inspection Reports in Correspondence Files, Movable Bridges, Bridge Preservation Section, WSDOT.

[33] P. J. Searles, "Footbridge With Bascule Draw," *Engineering New-Record* 90 (12 April 1923): 680.

[34] "The Bascule Bridge Turned Into an Amusement Device," *Engineering New-Record* 73 (18 February 1915): 354.

[35] Information regarding the life of Joseph B. Strauss is taken from the following: "Strauss, Joseph Baermann," *Dictionary of American Biography*, vol. 22, supp. 2. (New York: Charles Scribner's Sons, 1958), 636-37; "Strauss, Joseph Baermann," *National Cyclopedia of American Biography Being The History of the United States*, vol. B (New York: James T. White & Company, 1927), 332-33; "Strauss, Joseph Baermann," *National Cyclopedia of American Biography Being The History of the United States*, vol. 27 (New York: James T. White & Company, 1939), 30-31; "Strauss, Joseph Baermann," *Who Was Who in America--1897 to 1942*, vol. 1 (Chicago: A. N. Marquis Company, 1942), 1197.